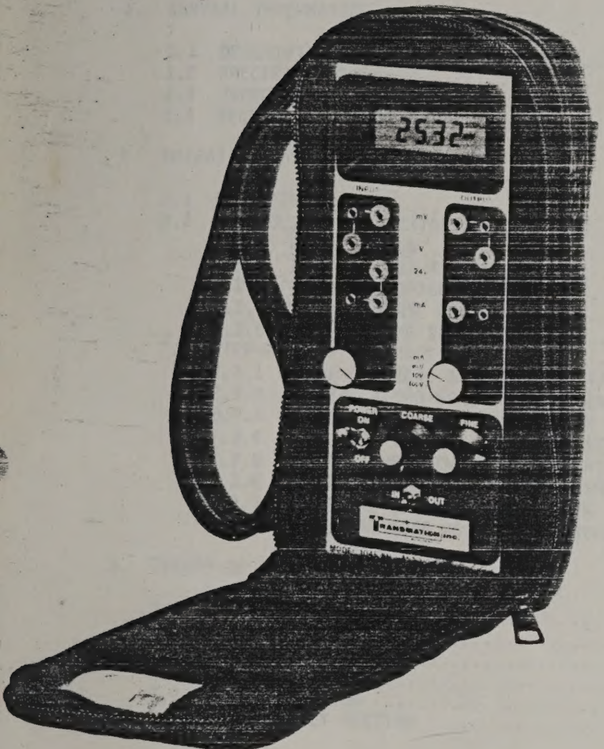
INSTRUCTION THAT SETS THE TREND

TRANSMATION inc.

ROCHESTER, N.Y. U.S.A.

INSTRUCTION MANUAL



MODEL 1045

DIGITAL CALIBRATOR AND SIGNAL INDICATOR

I.S. NO.: 100661-900

DATE: AUGUST, 1984

SUPERSEDES: NONE

FILE: TESTER

INTERFACE INSTRUMENTATION - DIGITAL/ANALOG

Analysis • Specifications • Design • Production

TRANSMATION inc.

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1.1 DESCRIPTION

This manual describes the Transmation Model 1045 Digital Calibrator and Signal Indicator. The 1045 is a battery-powered precision test instrument that is fully portable and well suited for field use. It comes equipped with a vinyl carrying case, test leads and a charger transformer assembly.

The 1045 simulates and/or measures process signals that fall within the millivolt, volt and milliamp ranges indicated in Specification 1.2.1. Input and output signal values are displayed on a four-digit liquid crystal display (LCD) on the 1045's front panel. The display mode (input or output) is selected via a toggle switch near the bottom of the front panel. In addition to displaying the input or output signal, the LCD automatically indicates the present display mode, the signal range in use and error conditions (low battery or overrange).

Each signal range has a separate set of terminals for input connections and output connections. This permits the user to operate the 1045 in the input and output modes simultaneously. For instance, the 1045 can be used to apply a mV test signal to a transmitter and simultaneously measure the transmitter's mA output signal. Range selection is done independently for the input and output sections via two rotary switches on the front panel.

In its mA output mode, the 1045 can simulate a two-wire transmitter. The 1045 can be inserted into a loop with an existing loop power supply (75 VDC maximum). In addition, the 1045 can measure the mA output of a two-wire transmitter while simultaneously powering the transmitter from the 1045's own 24 VDC supply.

The 1045 is powered by four "AA" nickel-cadmium batteries in a shrink-wrap package. By using a calculator-type wall transformer (supplied with the unit), the 1045's batteries can be recharged from a suitable AC line outlet. When the transformer is connected to an AC outlet, a built-in constant-charging circuit provides a constant 50mA current to recharge the depleted batteries. This constant supply permits the 1045 to be operated in any mode while simultaneously recharging the batteries and still maintain peak recharging rates. Two AC charger transformer assemblies are available: one is compatible with 117 VAC @ 60 Hz, while the other is suitable for 230 VAC @ 50/60 Hz. See the Recommended Spare Parts List in Section 1.4 for details.

1.2 SPECIFICATIONS

1.2.1 INPUT AND OUTPUT RANGE, RESOLUTION AND ACCURACY: See Table 1-1 below

1.2.2 INPUT IMPEDANCE:

mV: 10 megohms min.
V: 1 megohm min.
mA: 10 ohms ± 5%

1.2.3 OUTPUT IMPEDANCE:

mV: 0.5 ohms max.
V : 2 ohms max.
mA: True current source up to 500 ohm load

TABLE 1-1

INPUT/OUTPUT RANGE, RESOLUTION AND ACCURACY

TYPE	RANGE	RESOLUTION	ACCURACY
mV IN	-99.99 to +99.99 mV	0.01 mV	± (0.01% FS + 0.01% RDG + 1 LSD)
100 V IN	-99.99 to +99.99 V	0.01 V	± (0.01% FS + 0.01% RDG + 1 LSD)
10 V IN	-9.999 to +9.999 V	0.001 V	± (0.01% FS + 0.01% RDG + 1 LSD)
mA IN	-99.99 to +99.99 mA	0.01 mA	± (0.01% FS + 0.01% RDG + 1 LSD)
mV OUT	0 to 99.99 mV	0.01 mV	± (0.01% FS + 0.01% RDG + 1 LSD)
V OUT	0 to 9.999 V	0.001 V	± (0.01% FS + 0.01% RDG + 1 LSD)
mA OUT	0 to 22 mA into 500 ohms	0.01 mA	± (0.045% FS + 0.01% RDG + 1 LSD)

KEY: FS = Full Scale
LSD = Least Significant Digit
RDG = Reading

1.2.4 DRIFT:

Long Term (30 days): ± 2 LSD
Short Term (24 hrs.): ± 1 LSD

1.2.5 OUTPUT NOISE: Less than ± 1 LSD

1.2.6 COMMON MODE REJECTION (Input-to-Case): 120 dB min. @ 50/60 Hz

1.2.7 MAXIMUM COMMON MODE VOLTAGE: 250 VDC or peak AC

1.2.8 NORMAL MODE REJECTION: 60dB min. @ 50/60 Hz

1.2.9 INPUT PROTECTION:

mV/V IN: Can withstand up to 125 VAC

1.2.10 OUTPUT PROTECTION: Protected against output short circuit

1.2.11 INPUT/OUTPUT ISOLATION: 250 VDC or peak AC

1.2.12 STORAGE TEMPERATURE: -30°C to 60°C (-22°F to 140°F)

1.2.13 OPERATING TEMPERATURE: 0°C to 50°C (32°F to 122°F)

1.2.14 TEMPERATURE COEFFICIENT: 0.01% FS/°C

1.2.15 BATTERY: Four nickel-cadmium "AA" cells

1.2.16 BATTERY LIFE: 4 hours typical for 20 mA continuous output; 16 hours typical for all other modes

1.2.17 BATTERY CHARGE: Built-in constant-current charging circuit powered by external transformer, 14 hours typical to full charge

1.2.18 LOW BATTERY VOLTAGE: 4.7 volts typical; "LO BAT" message indicated on display

1.2.19 DISPLAY: 4 digit LCD with legends for Input, Output, Range, Low Battery and Overrange

1.2.20 INPUT/OUTPUT TERMINALS: Miniature banana plug

1.2.21 SIZE (HWD): 21.7cm x 8.6cm x 4.2cm (8.55" x 3.38" x 1.65")

1.2.22 WEIGHT: 0.8 kg (1.75 lbs.)

1.3 UNPACKING

It is recommended that all packing materials be retained in the event that the instrument must be returned to the factory. The instrument is shipped in its vinyl carrying case with a nickel-cadmium battery pack installed. Verify that the shipping carton contains:

- A Model 1045 Calibrator
- 2 sets of Test Leads
- A Model 1045 Instruction Manual, I.S. #100661-900
- An AC Charger Transformer
- Thermocouple Conversion Tables

1.4 RECOMMENDED SPARE PARTS LIST

ITEM	P/N
1045 Calibrator, not including carrying case, test leads or transformer	100661-000
Liquid Crystal Display	100661-050
1045 Instruction Manual	100661-900
Test Leads	500143-003
Wall Transformer, 117 VAC	502226-069
Wall Transformer, 230 VAC	502226-079
Coarse and Fine Control Dials	752011-005
Power Switch	759008-022
Display Selection Switch	759008-023
Input Range Selection Switch	759007-026
Output Range Selection Switch	759007-025
Battery Pack	759550-010
Carrying Case	759995-014

2.1 OVERVIEW

This section contains operating instructions for the Model 1045 Calibrator. Section 2.2 briefly describes the use of the front panel controls, terminals and display (see Figure 2-1 below). Section 2.3 contains step-by-step operating instructions for the various test applications (listed in the Table of Contents). Each set of instructions is accompanied by a connection diagram that shows the correct test circuit configuration.

2.2 CONTROLS AND INDICATORS

2.2.1 POWER SWITCH

To turn the power on, pull out the two-position locking toggle switch marked POWER, then move it up to the ON position. To turn the power off, pull out the toggle switch and move it down to the OFF position.

2.2.2 INPUT/OUTPUT TERMINALS

All input and output terminals are of the miniature banana plug variety. Those used for measurement (input) applications are located on the left side of the front panel, while those used for signal simulation (output) applications are located on the right side. The input side is isolated from the output side to permit simultaneous connection of test equipment to the input and output terminals. The positive (+) and negative (-) terminals are color-coded: RED = (+) and BLACK = (-). To conserve space on the front panel, certain signal ranges share a common negative terminal. Connecting lines drawn between the positive and negative terminals are used to indicate a shared negative terminal where applicable.

The terminal labeled 24V provides +24 volts with respect to the (-) mA IN terminal. When a two-wire transmitter is connected to the 24V and (+) mA IN terminals as shown in Figure 2-3 on page 4, the 1045 can measure the two-wire transmitter's mA output and simultaneously power the loop.

2.2.3 RANGE SELECTION SWITCHES

Range selection is done independently for the input and output sides of the 1045. A four-position and a three-position rotary switch are provided for that purpose. The mA output mode doubles as the two-wire transmitter simulate mode. When mA output is selected, the 1045 can be connected to an existing loop power supply (75 VDC maximum) or it can drive the current loop from its internal circuitry.

2.2.4 OUTPUT ADJUST CONTROL

Output signal amplitude is controlled by the Coarse and Fine knobs on the front panel. The table below indicates the adjustment ranges of the Coarse and Fine knobs for each output range.

OUTPUT RANGE	COARSE	FINE
mV OUT	0 to +99.99 mV	1.25 mV
V OUT	0 to 9.999 VDC	0.15 V
mA OUT	0 to 22 mA	0.4 mA

2.2.5 DISPLAY MODE SWITCH

One 4-digit liquid crystal display services both the input and output sides of the 1045. Display mode is switch-selectable via the two-position toggle switch near the bottom of the 1045's front panel. The selected display mode (input or output) is indicated on the display. The display also shows the signal range in use and error conditions as they occur. If the 1045's working range is exceeded, the display will automatically blank and the "OVRNG" legend will be displayed. When the battery needs recharging, "LO BAT" will be displayed.

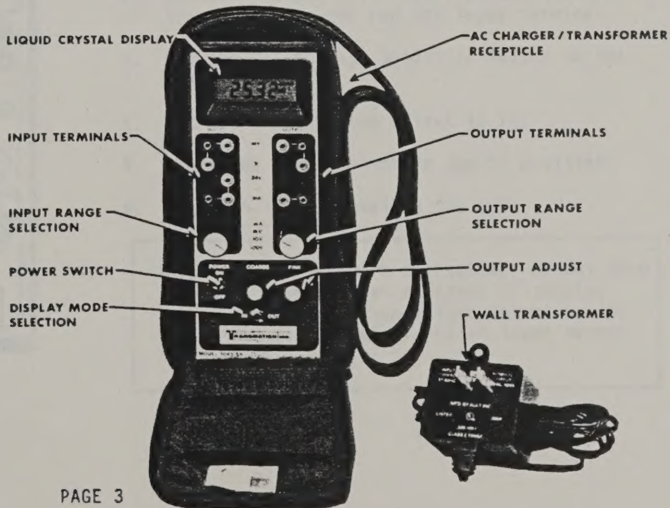

FIGURE 2-1
FRONT PANEL CONTROLS

2.3 STEP-BY-STEP OPERATING INSTRUCTIONS

Step-by-step instructions for operating the 1045 in the test applications listed in the Table of Contents are provided on pages 4 through 8.

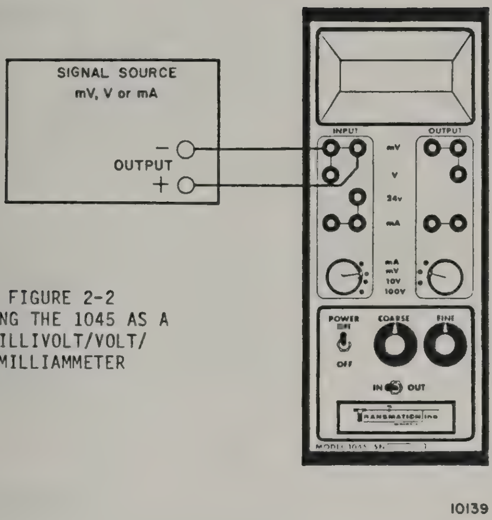

FIGURE 2-2
USING THE 1045 AS A MILLIVOLT/VOLT/ MILLIAMMETER

2.3.1 USING THE 1045 AS A MILLIVOLT/VOLT/MILLIAMMETER

1. Connect the negative lead of the signal source under test to either the black (-) mV/V input terminal or the black (-) mA input terminal on the 1045 as required.
2. Connect the positive lead of the signal source under test to the red mV, V or mA input terminal on the 1045 as required.
3. Set the Input Range Selection Switch on the 1045 to the range that matches the signal source's output.
4. Set the Display Mode Switch to IN.
5. Place the Power Switch in the ON position.
6. Read the input signal on the LCD.

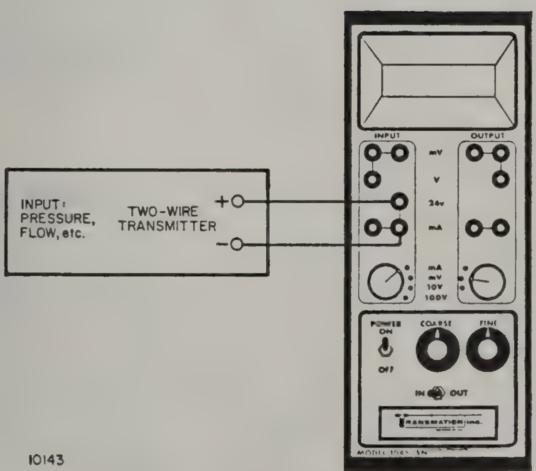

FIGURE 2-3
DRIVING A TWO-WIRE TRANSMITTER WHILE MEASURING THE OUTPUT

2.3.2 DRIVING A TWO-WIRE TRANSMITTER WHILE MEASURING THE OUTPUT

1. Connect the negative lead from the two-wire transmitter to the red mA input terminal.
2. Connect the positive lead from the two-wire transmitter to the red 24V input terminal.
3. Set the Input Range Selection Switch on the 1045 to mA.
4. Set the Display Mode Switch to IN.
5. Place the Power Switch in the ON position.
6. Read the input signal on the LCD.

NOTE:	If the two-wire transmitter output loop is driven by an existing DC supply, connect the transmitter output to the red (+) and black (-) mA input terminals.

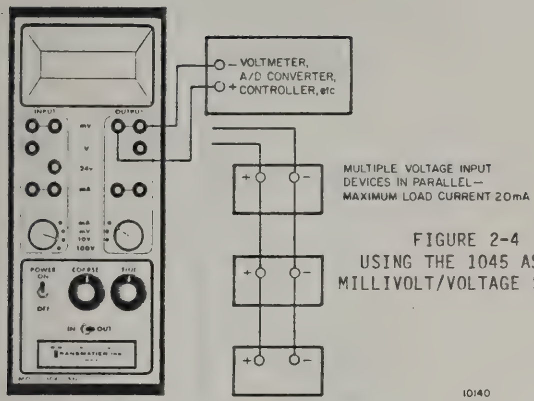

FIGURE 2-4
USING THE 1045 AS A
MILLIVOLT/VOLTAGE SOURCE

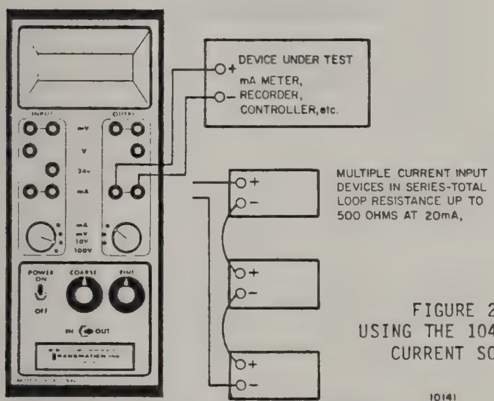

FIGURE 2-5
USING THE 1045 AS A
CURRENT SOURCE

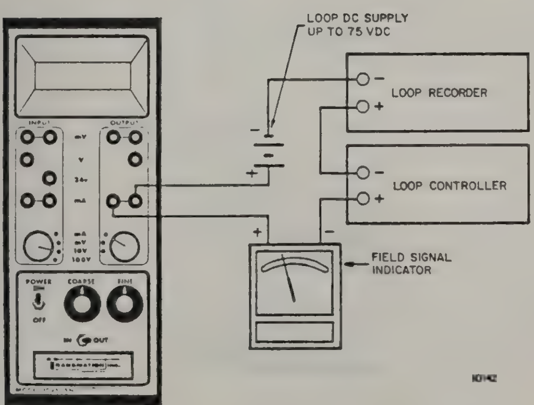

FIGURE 2-6
USING THE 1045 AS A TWO-WIRE TRANSMITTER SIMULATOR

2.3.3 USING THE 1045 AS A MILLIVOLT OR VOLTAGE SOURCE

1. Connect the negative lead from the instrument under test to the black (-) mV/V output terminal on the 1045.

2. Connect the positive lead from the instrument under test to the red (+) mV or V output terminal, depending on the instrument's signal range.

3. Set the Output Range Selection Switch to either mV or V, depending on the instrument's signal range.

4. Set the Display Mode Switch to OUT.

5. Place the Power Switch in the ON position.

6. Adjust the output signal amplitude using the Coarse and Fine control knobs.

7. Read the output signal on the LCD.

2.3.4 USING THE 1045 AS A CURRENT SOURCE OR A TWO-WIRE TRANSMITTER SIMULATOR

1. Turn the Coarse and Fine controls fully counterclockwise.

2. Connect the current input device(s) under test to the red (+) and black (-) mA output terminals on the 1045.

3. Set the Output Range Selection Switch to mA output.

4. Set the Display Mode Switch to OUT.

5. Place the Power Switch in the ON position.

6. Use the Coarse and Fine control knobs to adjust the mA output amplitude as required.

7. Monitor the output signal on the LCD.

NOTE: A typical two-wire transmitter simulator configuration is shown in Figure 2-6. If an existing DC power supply is not available, use the configuration shown in Figure 2-5.

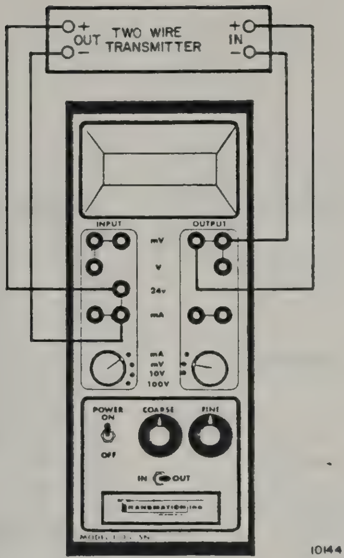

FIGURE 2-7
CALIBRATING A TWO-WIRE TRANSMITTER

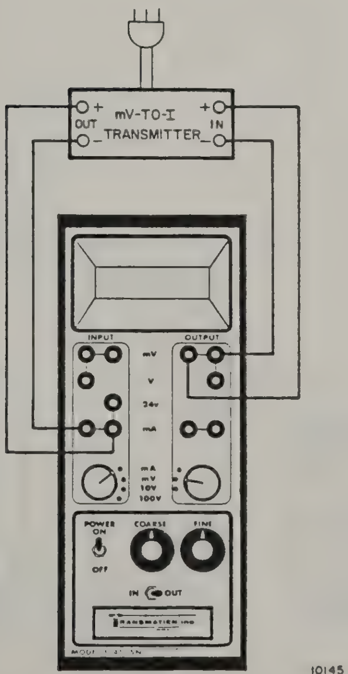

FIGURE 2-8
CALIBRATING A FOUR-WIRE TRANSMITTER

2.3.5 CALIBRATING A TWO-WIRE TRANSMITTER - SIMULTANEOUS INPUT AND OUTPUT

1. Connect the appropriate output terminals on the 1045 to the two-wire transmitter's input terminals (see Section 2.3.3 or 2.3.4).

2. Connect the two-wire transmitter's output terminals to the red (+) 24V input terminal and the red (acting negative) mA input terminal (see Section 2.3.2).

3. Set the Input Range Selection switch to mA, and set the Output Range Selection switch to either mV, V or mA as required.

4. Place the Power switch in the ON position.

5. Use the Coarse and Fine controls to adjust the input to the two-wire transmitter.

6. To monitor the input to the two-wire transmitter, set the Display Mode switch to OUT. To monitor the output of the two-wire transmitter, set the Display Mode switch to IN. Alternate the display mode using the Display Mode Switch as required.

2.3.6 CALIBRATING A FOUR-WIRE TRANSMITTER - SIMULTANEOUS INPUT AND OUTPUT

Use the procedure outlined above with the following exception: in Step 2, connect the transmitter's output terminals to the red (+) and black (-) mA, mV or V input terminals as required.

2.3.7 USING THE 1045 AS AN OHMMETER

By making use of the 1045's ability to measure an unknown signal and output a test signal simultaneously, it is possible to measure an unknown resistance. Measuring an unknown resistance with the 1045 involves driving a known current through the unknown resistance and measuring the voltage generated across the resistance. The unknown resistance can then be calculated using the formula: $R = V/I$.

To minimize the required arithmetic, use one of the following values for the known current signal: 0.01mA, 0.1mA, 1mA or 10mA.

In some cases, the voltage value read on the 1045's display can be translated directly into ohms. For instance, assume that the current output is 1mA and the mV input range is being used. A reading of 10mV = 10 ohms and a reading of 25mV = 25 ohms. In other cases, the voltage value read on the 1045's display must be multiplied by 10 or 100 or 1000 to obtain the unknown resistance value in ohms. For instance, assume that the current output is 1 mA and the voltage input range is being used. A reading of 1V = 1000 ohms and a reading of 0.5V = 500 ohms.

To set the 1045 up as an ohmmeter, consult Sections 2.3.1 and 2.3.4.

2.3.8 USING THE 1045 AS A THERMOCOUPLE SOURCE OR A THERMOCOUPLE INDICATOR

The 1045 can be used to calibrate thermocouple (T/C) devices or measure T/C signals. When thermocouple-to-copper connections are made at any temperature other than 0°C (32°F), error is introduced into the measurement and/or signal. Therefore, it is recommended that an ice point reference cell such as the Transmation Model 1010 or 1013 be used to compensate for the ambient temperature at the 1045's input and/or output terminals. When an ice point reference cell is not available, the amount of compensation required can be calculated. The measured and/or simulated signal can then be modified accordingly. This section describes how to use an ice cell with the 1045, or, as an alternative, how to calculate the required compensation. Thermocouple conversion tables that show the mV/temperature conversions for most T/C types are provided with the 1045.

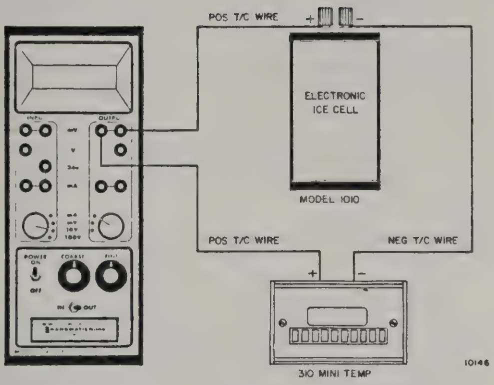

FIGURE 2-9a
USING THE 1045 AS A TEMPERATURE COMPENSATED mV SOURCE TO CALIBRATE A T/C INDICATOR

2.3.8.1 USING THE 1045 AS A T/C SOURCE WITH AN ICE CELL

1. Use the thermocouple tables to determine the mV equivalent of the temperature signal to be simulated.

2. Make the necessary connections between the 1045, the ice cell and the T/C device. Figure 2-9a shows the connections between the 1045, a Transmation Model 1010 Ice Point Reference Cell and a T/C indicator (Transmation Model 310 MiniTEMP®). Figure 2-9b shows the connections between the 1045, a Transmation Model 1013 Ice Point Reference Cell and a T/C transmitter (Transmation Model 3610T). In Figure 2-9b, the 1045 is being used to provide a T/C signal (type J) to the transmitter and measure the transmitter's resulting mA output. The Model 1013 is recommended for applications with type J, K and T thermocouples. The Model 1010 is recommended for all other types of thermocouples. Consult the appropriate instruction manual for detailed information (I.S. #100726-900 for the Model 1013 or I.S. #100720-900 for the Model 1010). Note that the red T/C lead is negative and the color-coded T/C lead is positive.

3. Set the 1045's Output Range Selection Switch to mV, and, if monitoring an input as well (as shown in Figure 2-9b), set the Input Range Selection Switch for the appropriate range.

4. Use the Coarse and Fine controls to adjust the output to the mV equivalent of the temperature value determined in Step 1.

5. Monitor the mV output on the 1045's LCD. If calibrating a thermocouple indicator such as the one shown in Figure 2-9a, a display is generally provided for monitoring the temperature. If calibrating a transmitter, the transmitter output (normally mA) can be monitored on the 1045's display.

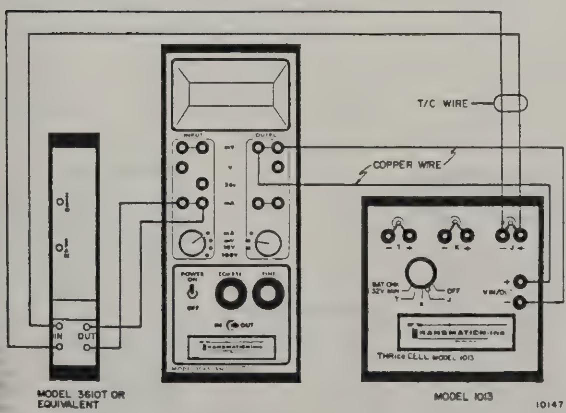

FIGURE 2-9b
USING THE 1045 TO CALIBRATE A T/C TRANSMITTER

2.3.8.2 USING THE 1045 AS A T/C INDICATOR WITH AN ICE CELL

1. Make the necessary connections between the 1045, the ice cell and the thermocouple (see Figures 2-10a and 2-10b below). Note that the red T/C lead is negative and the color-coded T/C lead is positive.

2. Set the 1045's Input Range Selection Switch to mV and read the input signal in millivolts on the LCD.

3. Use the thermocouple tables to convert the mV value to its temperature equivalent per T/C type.

2.3.8.3 SIMULATING A THERMOCOUPLE WITHOUT AN ICE CELL

1. Connect the 1045's mV output terminals to the T/C device under test, using the appropriate type of T/C leads (see Figure 2-11a below). Connect the red T/C lead between the negative (-) terminals and the color-coded lead between the positive (+) terminals.

2. Use the thermocouple tables to determine the mV equivalent of the temperature signal to be simulated per T/C type being used.

3. Use an instrument thermometer to measure the ambient temperature at the mV output terminals and convert the temperature to its mV equivalent per T/C type.

4. Subtract the mV value obtained in Step 3 from the mV value in Step 2.

5. Set the Output Range Switch to mV.

6. Use the Coarse and Fine controls to adjust the mV output to the value obtained in Step 4.

7. Monitor the output on the LCD.

EXAMPLE: Simulate a type J thermocouple signal of 337°F with an ambient temperature of 70°F.

T/C SIGNAL IN mV (STEP 2)		AMBIENT TEMP. IN mV (STEP 3)		COMPENSATED mV SIGNAL (STEP 4)
9.083mV	-	1.076mV	=	8.01mV

2.3.8.4 MEASURING A THERMOCOUPLE SIGNAL WITHOUT AN ICE CELL

1. Connect the T/C leads to the 1045's mV input terminals (see Figure 2-11b below). Connect the red T/C lead to the black (-) terminal and the color-coded T/C lead to the red (+) terminal.

2. Set the Input Range Selection Switch to mV and read the mV value on the LCD.

3. Use an instrument thermometer to measure the ambient temperature at the 1045's mV input terminals.

4. Use the thermocouple tables to convert the temperature value from Step 3 to its mV equivalent per T/C type.

5. Add the mV value in Step 4 to the mV value in Step 2.

6. Use the thermocouple tables to convert the resulting mV value in Step 5 to its temperature equivalent per T/C type.

EXAMPLE: Measure a type J thermocouple signal with an ambient temperature of 70°F.

STEP 2	STEP 4	STEP 5	STEP 6
VALUE DISPLAYED	AMBIENT TEMP. IN mV	COMPENSATED VALUE	ACTUAL T/C SIGNAL
8.01mV +	1.076mV =	9.086mV =	337°F

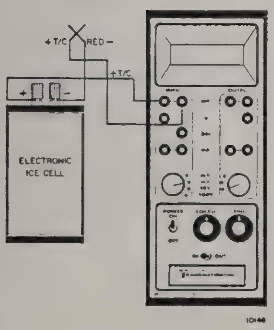

FIGURE 2-10a

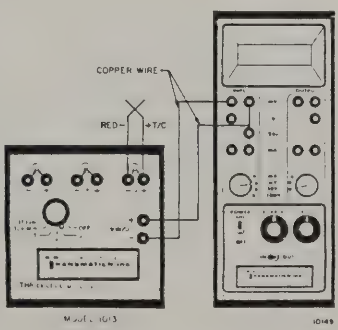

FIGURE 2-10b

THE 1045 AS A TEMPERATURE COMPENSATED T/C INDICATOR

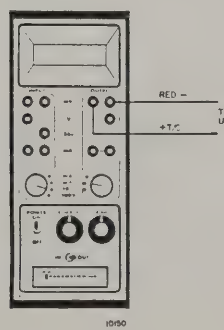

FIGURE 2-11a

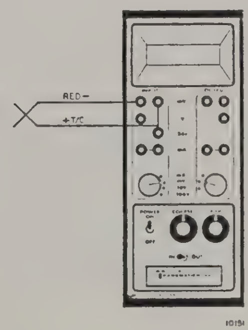

FIGURE 2-11b

DIRECT T/C CONNECTION

3. THEORY OF OPERATION

3.1 OVERVIEW

The 1045's circuitry is assembled on two PC boards: the display board and the power supply/DVM board. As the name implies, the power supply/DVM board contains the instrument's power supply and DVM sections. The display board contains the input, output and display sections. These boards are connected via three flat jumper strips: JA (14 lines), JB (8 lines) and JC (2 lines). The schematic diagrams for these boards are provided on pages 10 and 11. Brief descriptions of the various circuits on the boards are provided below.

3.2 INPUT SECTION

The input section conditions each analog input signal for compatibility with the instrument's DVM. Voltage and mA signals are scaled to 0-100mV. Millivolt signals require no scaling.

Switch S1-A is controlled by the Input Range Selection Switch on the front panel. It connects one set of input terminals at a time to the DVM section via pins 7 and 8 of JB.

Voltage signals are attenuated by the resistor network of R5, R6, R7, R44 and R45. R6 and R44 are adjusted to provide the precise attenuation factor needed to scale the voltage down to 0-100mV. Milliamp signals are scaled by resistors R1-R4 such that 1mA at the mA input terminals represents 1mV at the DVM.

3.3 OUTPUT SECTION

The output section generates a signal within one of the specified signal ranges depending on the position of S2-A. S2-A is controlled by the Output Range Selection Switch on the front panel. It connects the appropriate resistor to the output amplifier's (A1) feedback loop. For instance, when mV OUT is selected, R24 is used; when V OUT is selected, R20 is used; and when mA OUT is selected, R15 is used.

R13 and R11 are both 3 3/4-turn potentiometers. They serve as the Coarse and Fine Output Adjust controls, respectively. Q2 and R27 limit the current through Q1 to approximately 27mA.

Switch S2-B is also controlled by the Output Range Selection Switch. It makes the output signal available for display when switch S3 is appropriately positioned. S3 is controlled by the Display Mode Switch on the front panel. Voltage and mA output signals must be properly scaled for compatibility with the DVM in much the same manner as the voltage and mA input signals. R21, R22 and R23 scale the voltage output signals while R16-R19 scale the mA output signals.

3.4 DVM SECTION

Analog signals (0-100mV) from the input and output sections are converted to BCD digits and are transmitted to the display section by the DVM (A1). The DVM provides four BCD digits that are multiplexed so that only one digit appears on the DVM output lines at one time. The BCD code and various display control signals are transmitted to the display section via jumper strip JA.

Millivolt level signals from the input and output sections are buffered and amplified by a CMOS buffer amplifier (A2). A2 has a gain of 10 and amplifies the millivolt signals to 0-1V. In addition, A2 has a very low susceptibility to zero drift. Therefore, no zero reference circuitry is required. Overvoltage protection is provided by CR6, CR7, CR9 and CR10. A6 is used to detect overrange conditions and transmits the appropriate control signal to the display section. The DVM's A/D converter runs on a 100 KHz clock signal.

3.5 DISPLAY SECTION

The display section includes a 4-digit liquid crystal display, four BCD-to-seven segment decoders, a low battery detection circuit and a display legend driver circuit. The BCD code from the DVM is applied to all four decoders (A5-A8) simultaneously. Only one decoder is enabled at a time as determined by the digit drive lines from the DVM (D1-D4).

The display also has provision for displaying certain messages and/or symbols that indicate mode of operation, signal range, polarity and error conditions. Two separate circuits are used to drive those portions of the display. The low battery detection circuit compares the battery voltage (V_D) with a precision reference voltage (V_R). When V_D drops below 4.75V, the "LO BAT" message is displayed. The display legend driver comprises numerous logic gates (A2 and A3) that detect mode of operation (IN or OUT), range (mV, mA or V), polarity and overrange (OVRNG).

3.6 POWER SUPPLY SECTION

Power for the input, output, DVM and display sections is provided by four "AA" nickel-cadmium cells. Transformer 1 is used to provide isolation between the input, output and power sections. The input and output sections tap the primary coil of T1 to obtain their required operating voltage using separate secondary coils. The digital circuitry in the DVM and display sections obtain their required voltage directly from the batteries.

The battery charging circuit is comprised of op-amp A7, transistor Q3 and their associated components. When the transformer is connected to a suitable AC line outlet, the circuit provides a constant 50mA current to recharge the depleted batteries. This constant supply permits the 1045 to be operated in any mode while simultaneously recharging the batteries without affecting the recharge time.

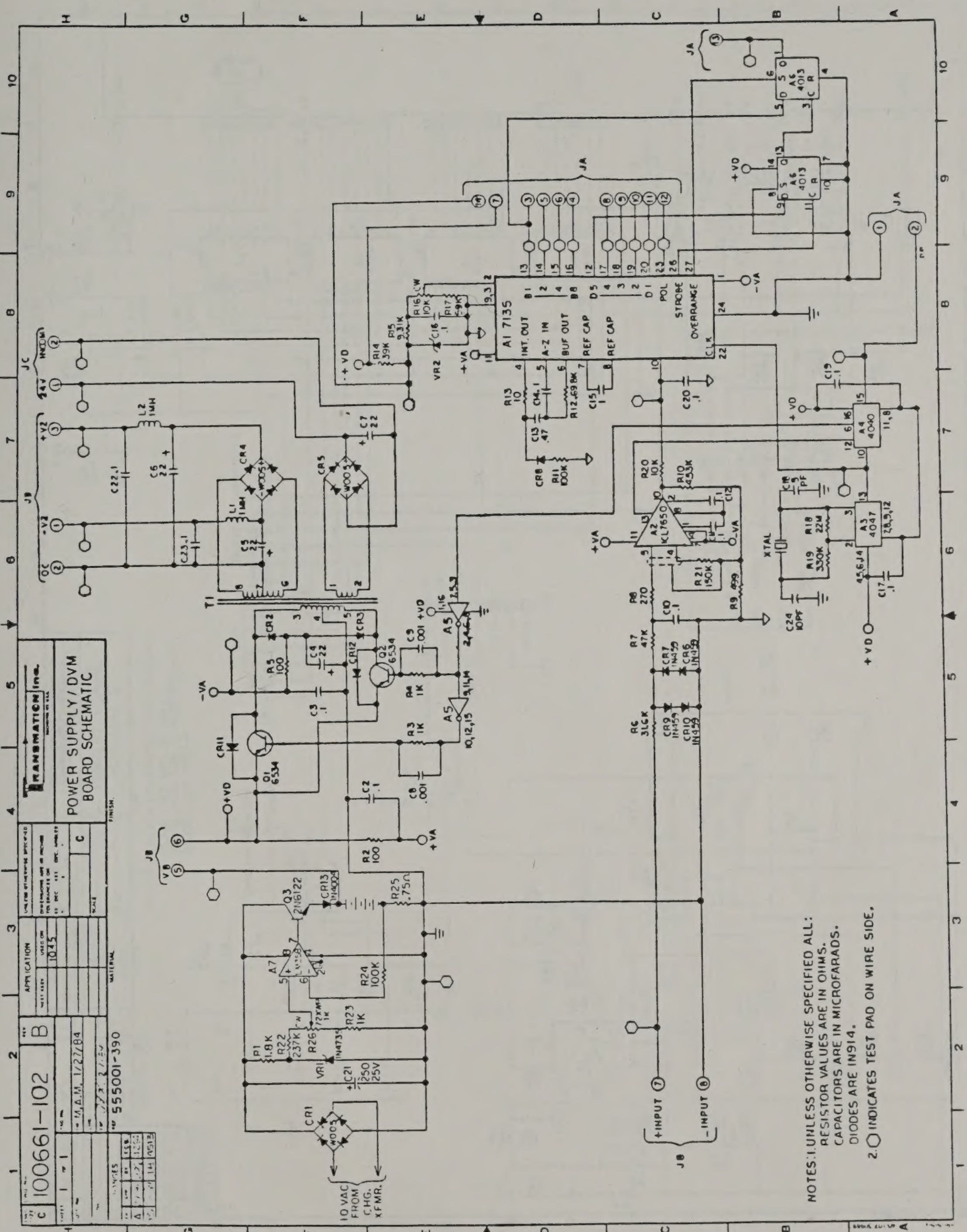

FIGURE 3-1
POWER SUPPLY/DVM BOARD SCHEMATIC

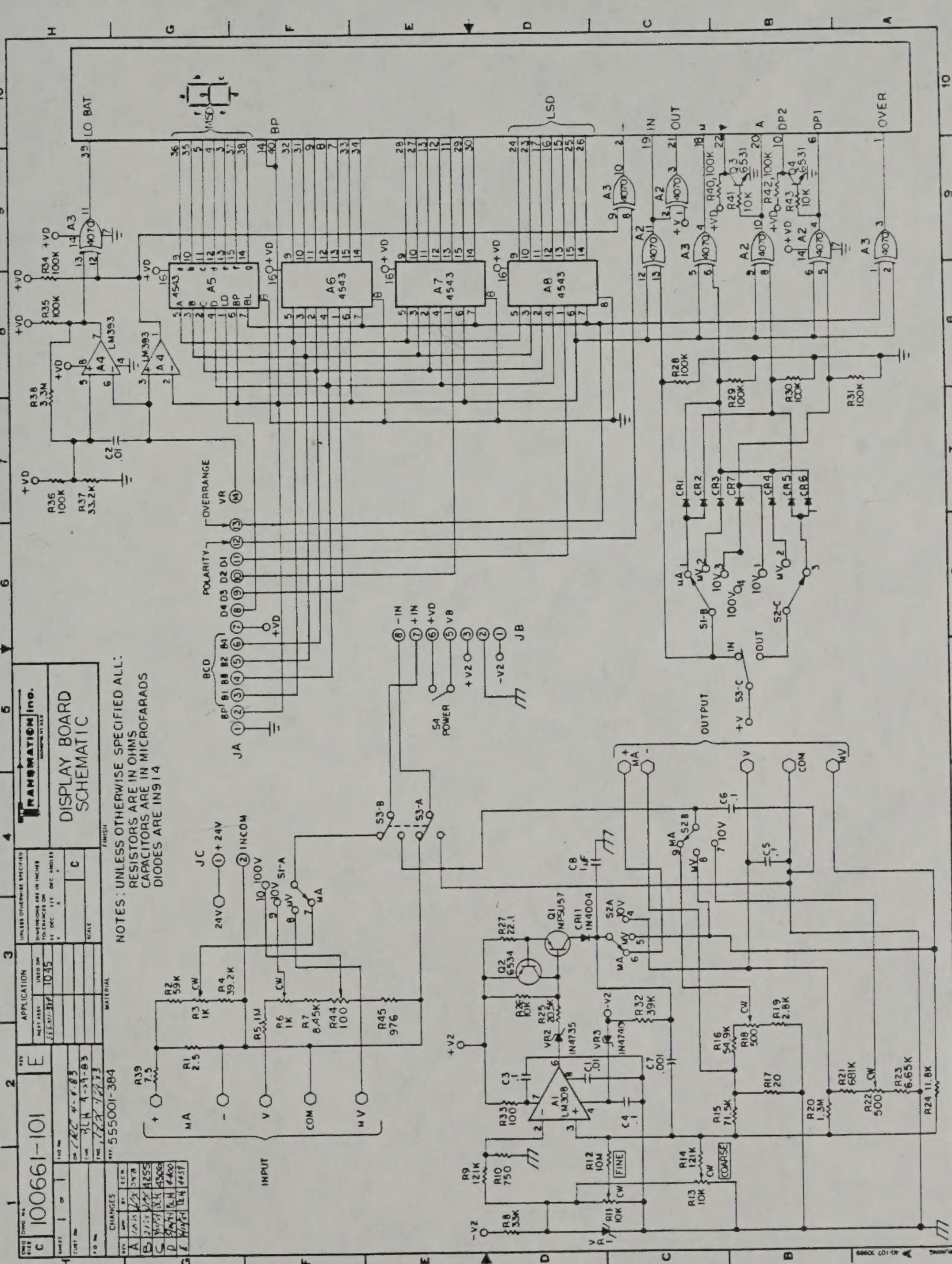

FIGURE 3-2
DISPLAY BOARD SCHEMATIC